Emission and Transport of ^{137}Cs from Boreal Biomass Burning

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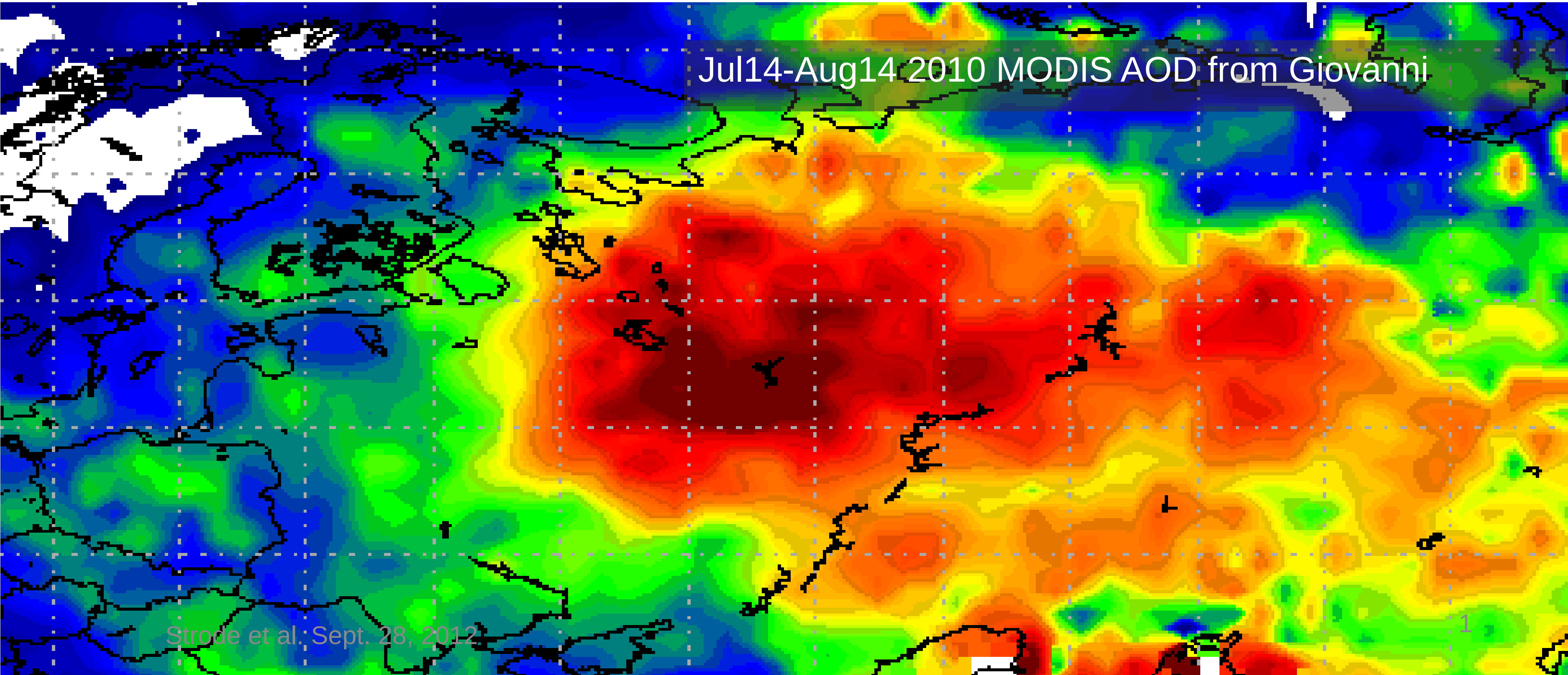


Background

Cs-137

- Radionuclide with 30 year half-life
- Harmful to human health
- Persistent in northern ecosystems --> potential remobilization during fires

•Concentrations peaked in 1960s due to nuclear tests

•Additional source in 1986 from Chernobyl accident

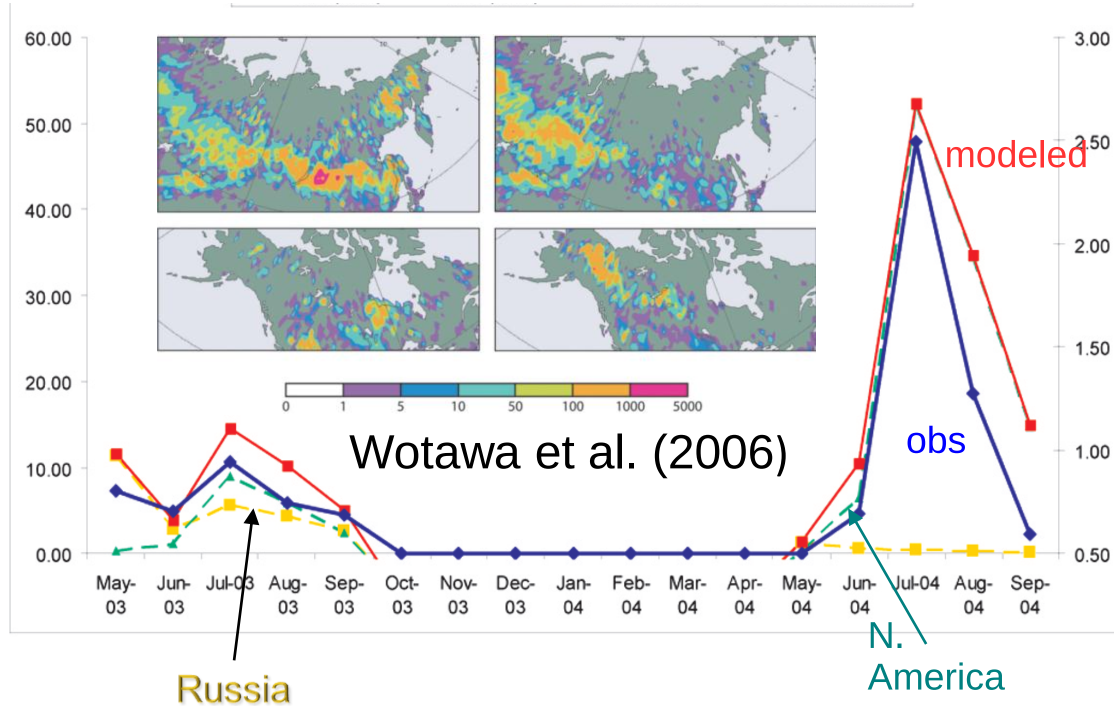
•Source from Fukushima in 2011

This Study: Summer of 2010

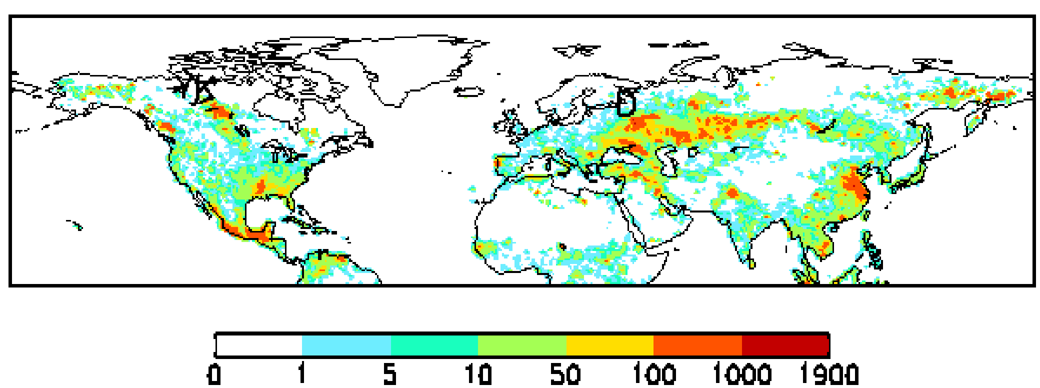
- ^{137}Cs levels generally below detection limit
- Intense wildfires in western Russia

Cs-137 and Biomass Burning

- Biomass burning can volatilize ^{137}Cs back into the atmosphere
- Wotawa et al. (2006) linked ^{137}Cs detection in Yellowknife, Canada to boreal biomass burning in Siberia and North America
- Do we see enhanced ^{137}Cs in the summer of 2010?
- Cs-137 data from the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) radionuclide monitoring stations
- Most stations have few detections – focus on Dubna & Yellowknife

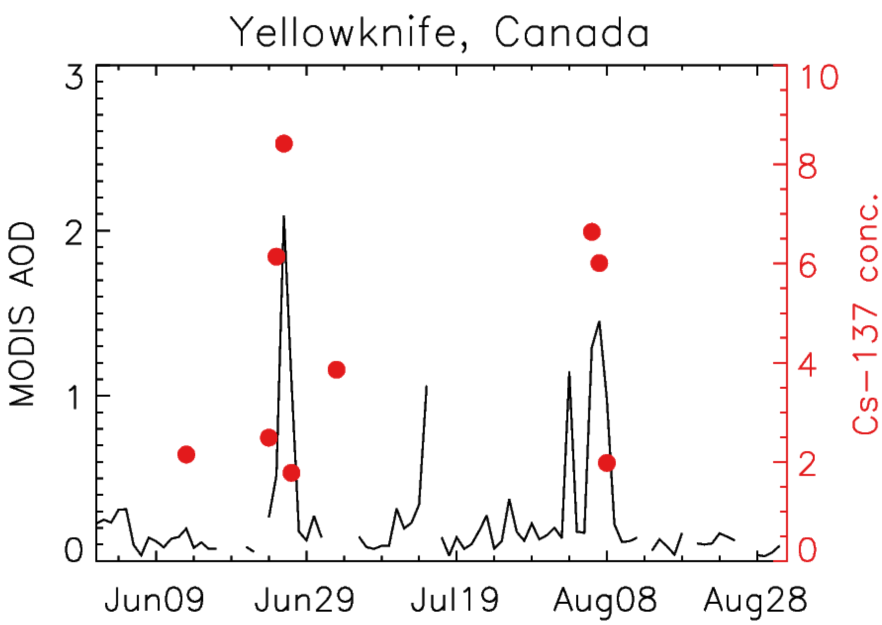


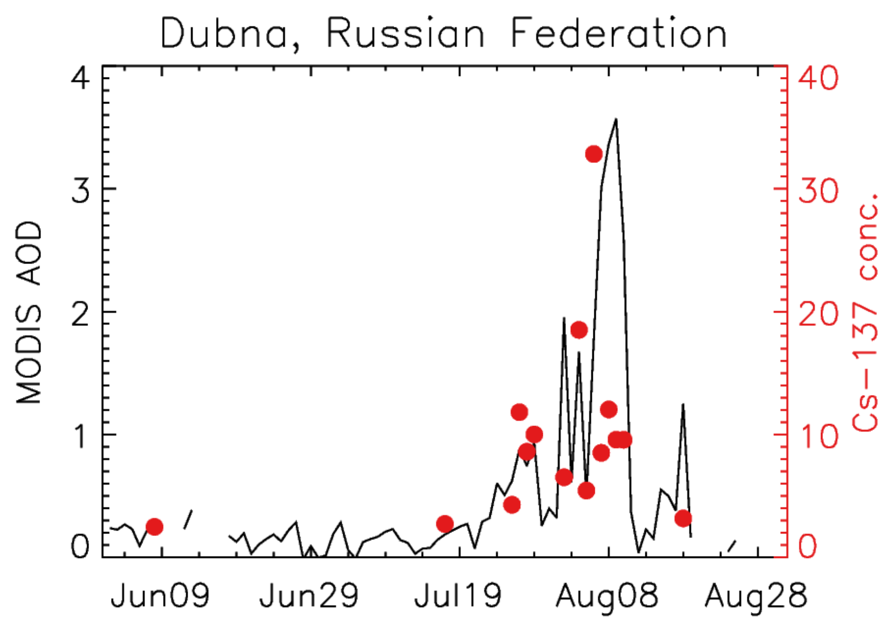
May-Sept. 2010 MODIS fire counts



^{137}Cs vs Aerosol Optical Depth (AOD)

- 550 nm AOD from MODIS-Aqua v5.1
  - satellite has afternoon overpass
  - Global coverage ~daily
  - Gridded data downloaded from the Giovanni online data system, developed and maintained by the NASA GES DISC
- Cs-137 obs from CTBTO Monitoring stations
- Cs-137 peaks corresponding to high AOD





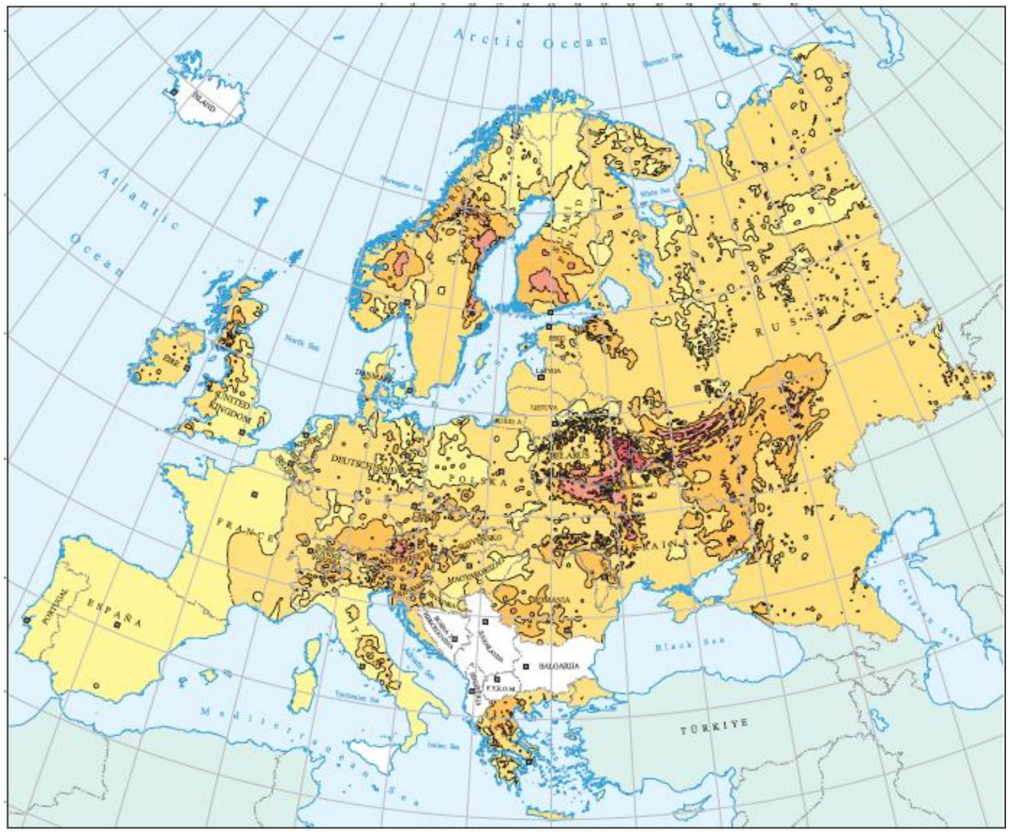
Cs-137 Modeling

- Use global model to attribute sources and estimate emissions of Cs-137
- GEOS-5 global atmospheric model constrained by observed meteorology (MERRA analysis) at 1x1.25 degree resolution
- Cs-137 binds to particles → Aerosols from GOCART model
- Biomass burning from the GFED3 inventory, adjusted to better reproduce observed AOD
- Use Cs/OC emission ratio to relate modeled particulate organic matter (POM) to Cs-137 concentrations

Tagged tracers for Cs

- Inhomogeneous surface distribution of Cs-137
- Do specific regions drive atmospheric detections, or all boreal biomass burning?
- Tagged BB tracers for N. America, Western Russia, 40-50N (high Cs band), areas of enhanced contamination

Cs-137 deposition over Europe



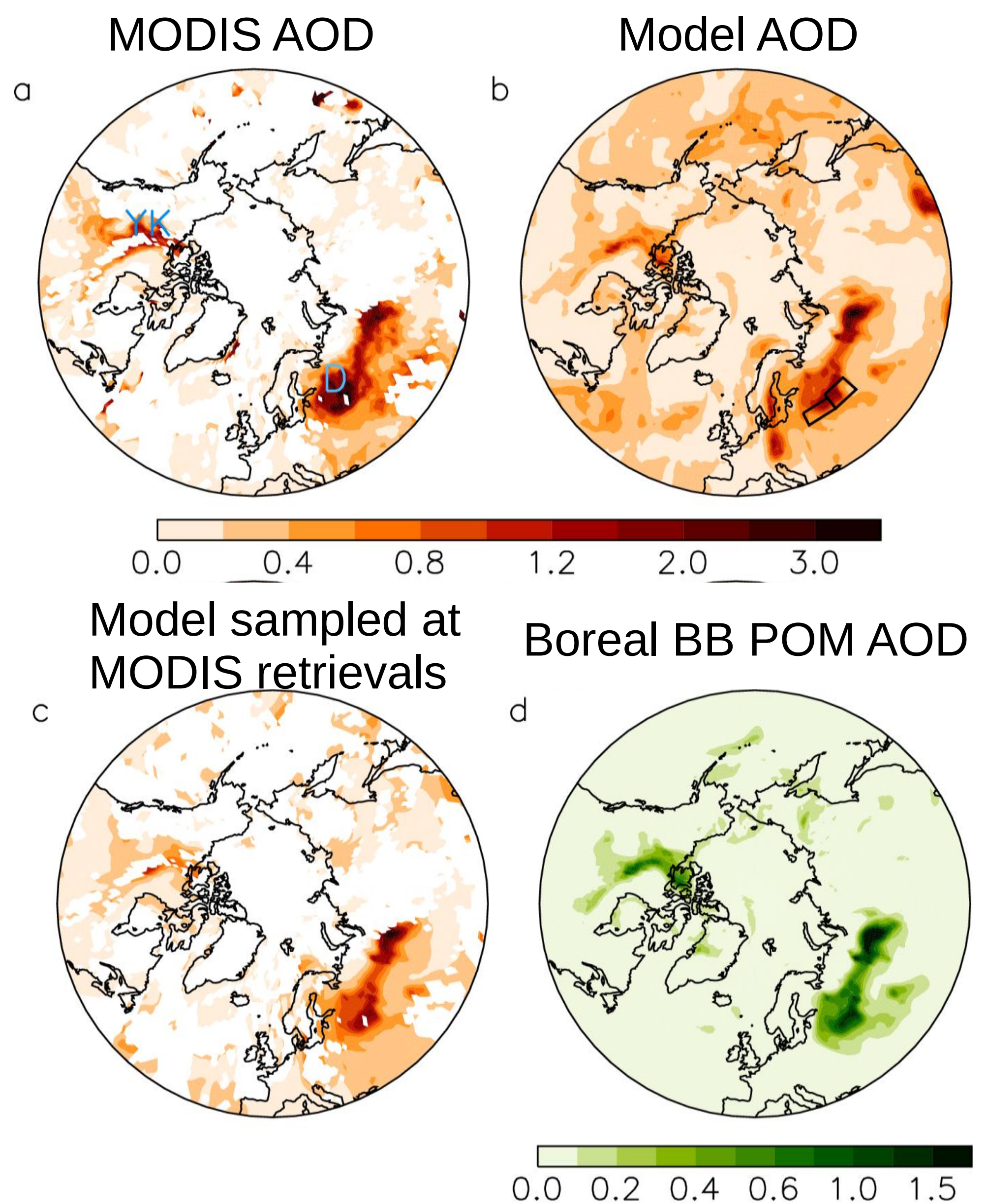
UNSCEAR Report, 2000

Modeled and Observed AOD

Model reproduces aerosol optical depth enhancements over Russia and Canada

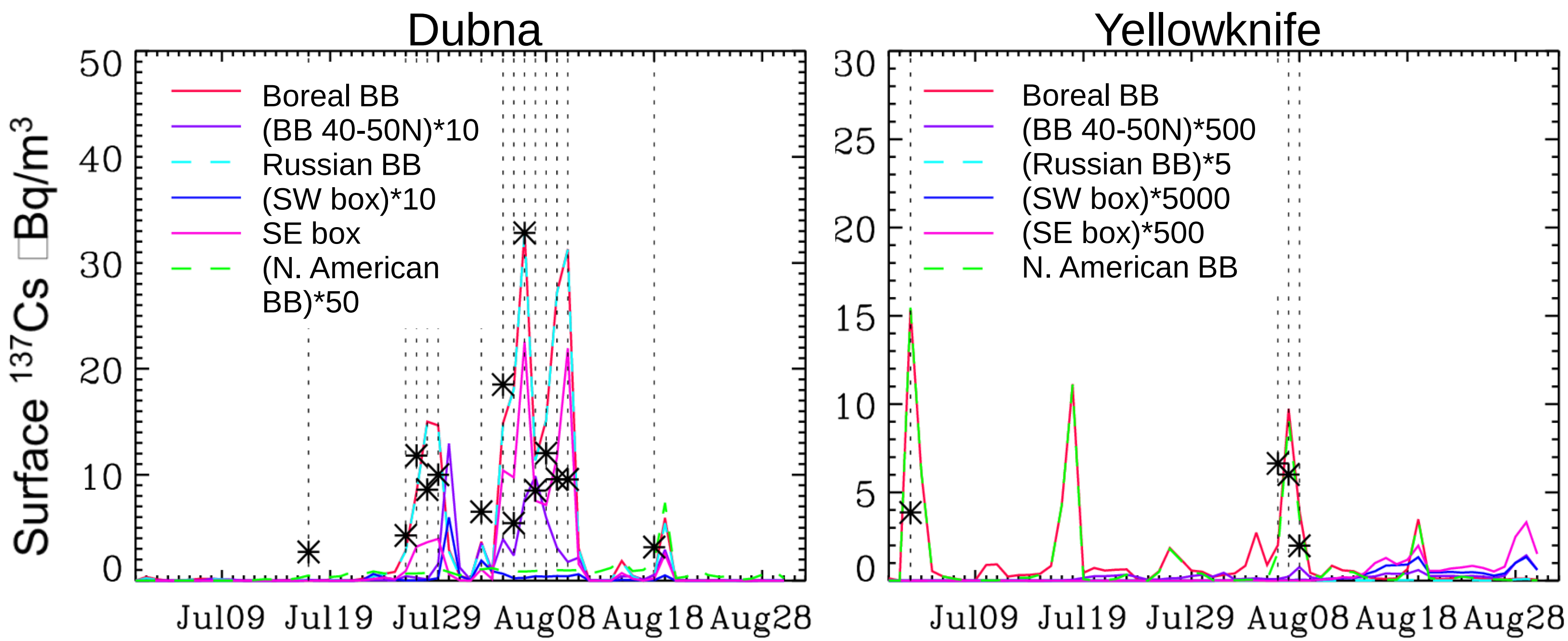
Model's enhanced AOD driven by boreal biomass burning (BB)

Yellowknife and Dubna stations located in areas impacted by biomass burning



Strode et al. [2012]

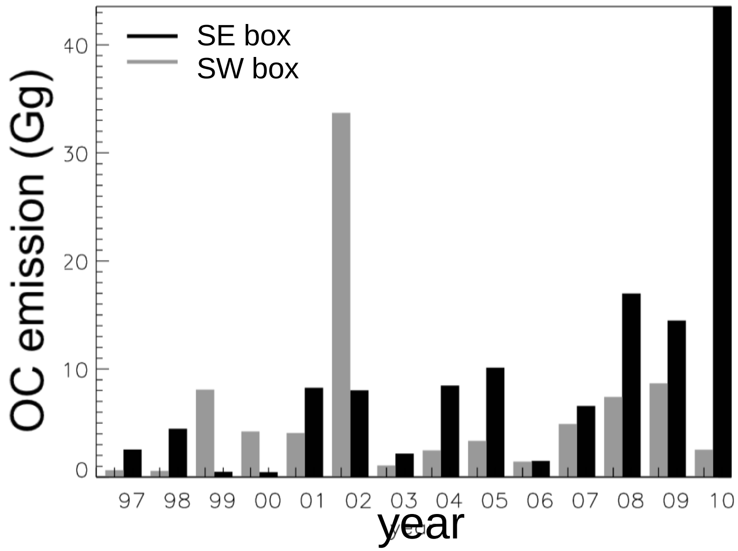
Tagged Tracer Contributions



Strode et al. [2012]

- Western Russian biomass burning tracer dominates total Cs-137 at Dubna, explains ~50% of variance
- N. American biomass burning dominates at Yellowknife
- Strongest correlation at Dubna is for SE box, low correlation for SW box

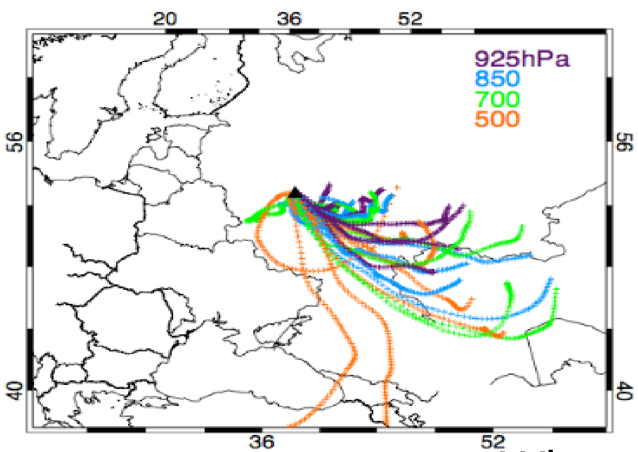
Cs-137 from the Southeast Box

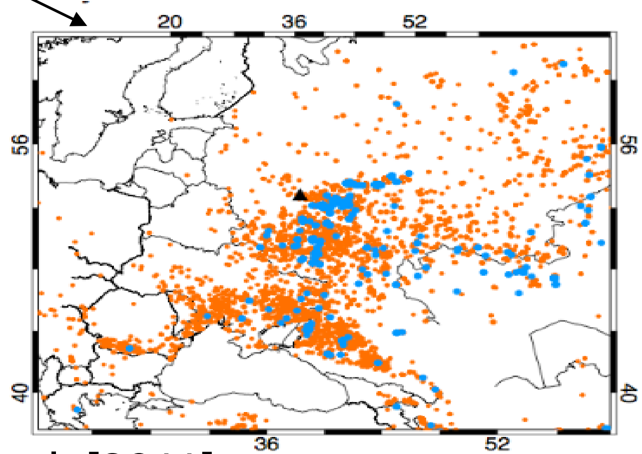


GFED3 inventory shows anomalously high organic carbon emissions from the SE box in 2010

Strode et al. [2012]

Meteorology and fire locations (shown in figure from Witte et al. below) can explain strong correlation with SE tracer

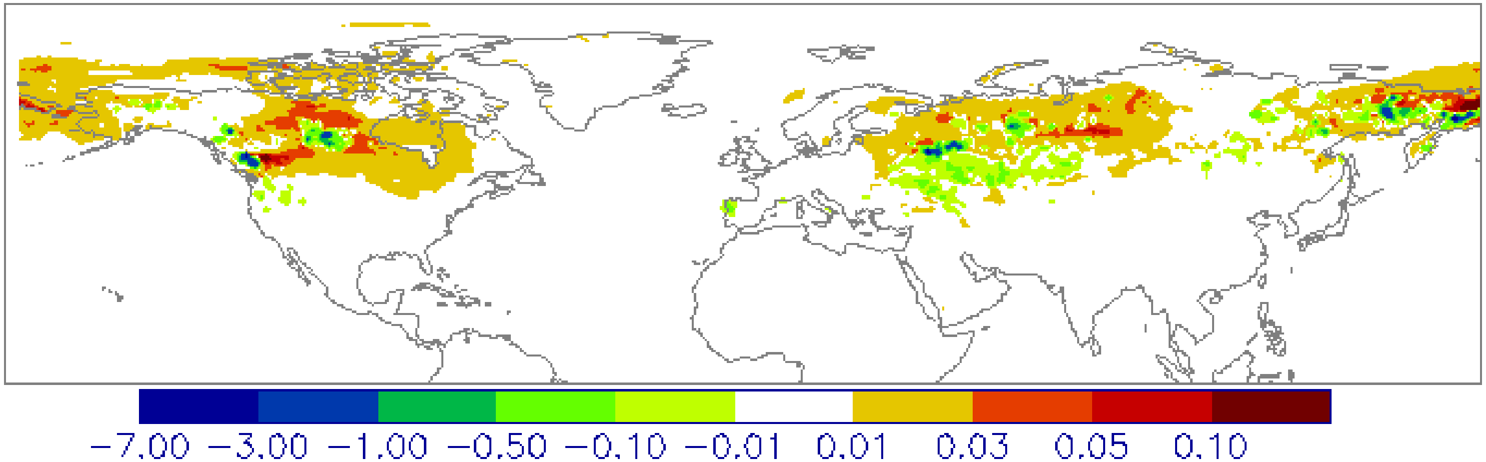




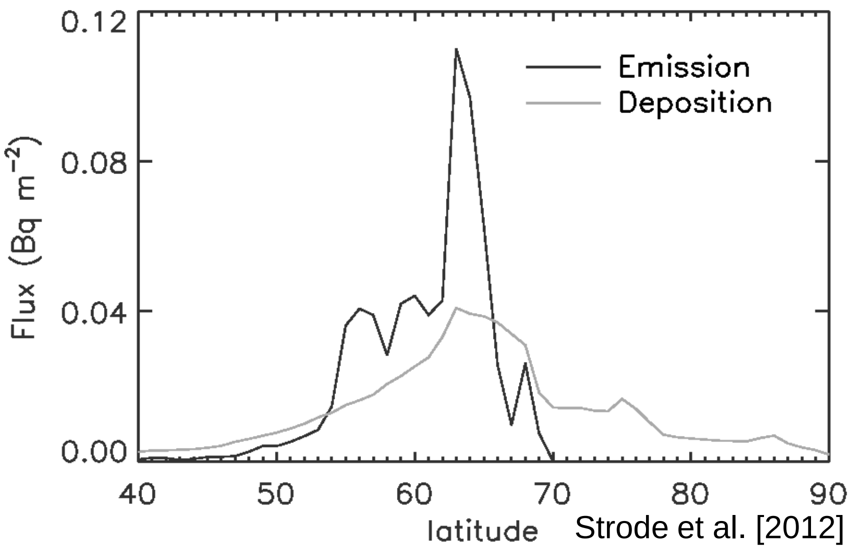
Witte et al. [2011]

Redistribution of Cs-137

Deposition - Emission



- Atmospheric transport redistributed ^{137}Cs over a broader region
- Northward shift
- Small effect



Strode et al. [2012]

Conclusions

- Cs-137 detections correlated with aerosol optical depth during 2010 wildfires
- Model atmospheric particulate transport & deposition of Cs-137 from 2010 wildfires based on organic carbon
- Model captures broad spatial patterns of AOD seen by MODIS and daily variability in Cs-137
- Best-guess estimate of 1.5×10^{12} Bq Cs-137 emitted
- Small northward redistribution of Cs-137